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Kaolinization of 2:1 type clay minerals with different swelling properties

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Abstract

Kaolinization of 2:1 type clay minerals commonly occurs in the supergene environments of the Earth, which plays critical roles in many geochemical and environmental processes. However, the transformation mechanism involved and the specific behavior of 2:1 type swelling and non-swelling clay minerals during kaolinization remain poorly understood. In this study, laboratory experiments on the kaolinization of montmorillonite (swelling), illite (non-swelling), and rectorite (partially swelling) were carried out to investigate the kaolinization mechanism of 2:1 type clay minerals and to evaluate whether swelling and non-swelling layers of 2:1 type clay minerals perform differently or not in their kaolinization processes. The results show that montmorillonite, illite, and rectorite in acidic Al^{3+}-containing solutions can be transformed into kaolinite, whereas such transformation is hard to take place in Al^{3+}-free solutions. Part of the Al^{3+} in the solutions was exchanged into the interlayer spaces of swelling clay minerals at the early stage and resulted in the formation of hydroxy-aluminosilicate (HAS) interlayers, but they show no influence on the transformation process. Interstratified kaolinite-smectite (K-S), kaolinite-illite (K-I), and kaolinite-rectorite (K-R) formed as the intermediate phases during the transformations of the three different precursor minerals, respectively. The results obtained in this study demonstrate that 2:1 type clay minerals, including both swelling and non-swelling ones, can be transformed into kaolinite via a local dissolution-crystallization mechanism, which starts mainly from the layer edges rather than the basal surfaces. Due to different dissolution rates from domain to domain within a precursor mineral particle, the layers with a low dissolution rate become "splints," while the dissolved elements are concentrated between two "splints," leading to precipitation of kaolinite along the basal surfaces of precursor minerals. The size and stacking order of the newly formed kaolinite strongly depend on the morphology and property of the precursor minerals. These findings not only are of importance for better understanding the transformation procedures between different clay minerals and the mechanisms involved but also provide new insights for well understanding mineral-water interactions that are central to all geochemical processes.

Keywords: Clay mineral, kaolinization, swelling property, dissolution-crystallization, mineral-water interaction